International Journal Of Engineering Research And Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 17, Issue 4 (Jul. – Aug. 2021), PP. 28-38

Evaluation of salinity effect on growth and productivity of Rhodes grass (*Chloris gayana*)

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ABSTRACT: *For many years, saline lands have been a problem for agricultural investment, so this study aimed to evaluate the growth and productivity of Rhodes grass under the conditions of the environmental stress of salinity on two types of soils (sandy soil and sandy clay soil) in Wadi Al Shate region (in southern Libya) in summer 2013. By determining the percentage germination and growth indicators of seedling and measurement of some of the apparent characteristics of the vegetative and root, as well as the study of the most soil characteristics affecting plant growth. The results showed the ability of the plant to grow during soil salinity up to 300 mM/L sodium chloride but with significant damage, and it is noticed that it excretes these salts through the vegetative part of the plant. The results also showed adverse effects of salinity stress on plant height; stem thickness, surface leaf area, percentage of dead plants, and percentage of plant moisture content. Saline stress had adverse effects on root depth and density. It had a high ability to extend their roots quickly during its first stages of growth, during 30 days and characterized by a great radical cohesion. Salinity also harms soil acidity and organic matter, the electrical conductivity of the soil increased by salinity. Sandy soil found to have a positive effect on the growth and depth of Rhodes grass.*

KEYWORDS*: Growth**,** Productivity**,** Rhodes Grass, Salinity.*

Date of Submission: 20-06-2021 Date of Acceptance: 05-07-2021

I. INTRODUCTION

Saline lands are important because of the widespread in the world and their production capacity affected by the presence of salts for either quantity or quality. In addition to the presence of a high concentration of salts with salt crust on their surface, they vary in composition and appearance according to the prevailing salt type, soil moisture, and humus content. Moreover, the plants appear scattered and varying degrees of growth, have a dark green colour and matured early and low productivity, and may not produce anything, depending on the concentration of salts (Balbaa, 1995).

However, Saline lands characterized by poor physical characteristics where the height of dissolved salts concentration into the degree of influence plant growth in general. Also, the poor permeability limits the movement of water through the soil due to the exchangeable sodium increasing. The salinity of the agricultural lands is a global problem. There is hardly any country without them, especially in arid and semi-arid regions. Salinity has an indirect effect because of the effect of salts on the plant growth environment and not on the growth of the plant itself. The increase in salts concentration increases the amount of osmotic pressure in the root area and thus weakens the ability of the plant to absorb its water needs, but the salt-loving plants do not suffer from lack of water because the accumulation of salts in the juice cell increases its pressure osmotic equal pressure of the soil solution affected by salts. The direct effect is shown on the quality of the crop and the toxic effect of some elements that appear on the plant parts due to its increased concentration (Al shok and Abdul kadhim, 1990).

The majority of the Arab countries are located in the arid and semi-arid lands of the region (Nassar, et al., 2007) and the salinity of the land in these areas is one of the main problems of agricultural production (Balbaa, 1995). In 1997, Taleisnik and Peyrano studied the effect of salinity on plant seedling and growth, post-harvest growth and accumulation of ions on a variety of *Chloris gaiana* species and found that water intake in seeds was not affected by salinity (0-400 mM/L NaCl). Saline solution delayed or inhibited germination of all species and seeds of all these species maintained growth potential at 100 and 200 mM/L NaCl and percentage of germination occurred after transfer to distilled water where it reached less than 60% and growth in species decreased in high salinity. Moreover, cv. Boma was the most sensitive and had a relatively lesser content of sodium and more accumulation of potassium in the leaf tissue and less ability to excrete sodium through saline glands.

Waisel (2006) also studied the effects of sodium chloride for the growth of Rhodes grassroots. The results showed that Rhodes grass is a saline-tolerant fodder and is more similar to salinity-tolerant plants and its growth is favourable at low levels but sensitive to high salinity levels. Malkin and Waisel (2006) assessed the effect of high salt stress on Rhodes grass seedlings to select saline resistance species and to identify the differences between indigenous and currently available plant communities. Five generations of seedlings grown on agricultural sands and irrigated with sodium chloride solutions to a concentration of 0.7 mM. The surviving plants were the most successful in each generation until maturity and seed production. The results showed that the fifth-generation plants of the selected communities showed significant improvement in viability and post-harvest regeneration. Some effects found on seed culture and water efficiency and not significant differences found between the original and fifth-generation plant communities in terms of ionic content and protein building. Data indicated that Rhodes grass's survival during salinity stresses improved plant regeneration after multiple harvests and successive generations of this plant species.

A report of the Australian Queensland Government of Australia (2009) reported that the critical electrical conductivity value of the mean root area salinity of the productivity decreases Rhodes grass 7.0 ds/m was critical for the decrease in plant growth in the sand was 12.8 ds/m, silt 3.7 ds/m and clay 4.2 ds/m. The objective of this study is to evaluate the growth and productivity of Rhodes grass under the conditions of the environmental stress of salinity using two different types of soils in Wadi Al-Shate region (Southern Libya) by assessing the effect of salinity on the plant ecophysiology.

II. MATERIALS AND METHODS:

2. 1. Materials used:

Soil: Two types of common soil used in Wadi the Shate region, namely sandy soil and sandy clay soil and it is physicochemical shown in table 1.

Table 1: properties of sandy and sandy clay soil

soils	pH	EC ds/m	O.M %	CEC Mq/100g
sandy	6.15	1.21	1.19	0.71
Sandy clay	6.59	6.35	1.86	1.2

Plant: Callide Rhodes grass (*Chloris gayanaKunth*) (Grice, 2000).

2. 2. Germination experiments:

Germination experiments carried out on Rhodes grass seeds using 11 cm diameter Petri dishes. Ten seeds were placed on filter paper moistened with different concentrations of 5 replicates per sodium chloride concentration (100 – 200 -300 - 400 mM/L) and control treatment (0mM/L NaCl) for 10 days. The percentage of germination was calculated every 24 hours (Danthu, *et al.*, 1991) for 10 days. The percentage of germination was calculated (where the emergence of the radicle or rosette considered indicating germination from the first day to the tenth day) using the following formula**:**

Percentage of germination = (number of germinated seeds) / (total seeds number) x 100

Seedling growth: After germination of the Rhodes grass seeds, the length of the radicle, rosette, rhizomes (the air stem) and the secondary root every 24 hours over 10 days for all treatments and all replicates**.**

2. 3. Plant growth:

The seeds of Rhodes grass were grown 20 kg/ha in dark plastic tubes, 50 cm long and 15 cm in diameter (1 g/tube) as in the method used by Bruce (2007)**,** the pipes contain two types of soils (sandy soil and clay-sand soil). Planting was carried out under the natural conditions of the study region and irrigated with an entire field capacity of 1900 and 2700 ml of water for sandy and sandy clay soil respectively, daily the first ten days to ensure the highest germination rate.

After the plants reached about 3 cm in length, the combined fertilizer was added to 100 kg/ha (5 g per tube) followed by adding nitrogen fertilizer at 100 kg/ha (5 g per pipe) a week after, as the method used by Bruce (2007)**.** After 30 days of planting Rhodes grass, Plants were subjected to a cycle of saline stress by (0 - 100 - 200 - 300 - 400 mM/L) of sodium chloride in the entire field capacity of sandy soil and sandy clay soil based on 5 replicates per treatment for each soil type of 50 days.

During this period, some indicators of vegetative and root growth were measured, as well as some physical and chemical properties of soils.

2. 4. Laboratory analysis:

The plant: Samples were taken immediately after the harvest to the laboratory and the percentage of moisture content was estimated. Other samples were dried by air, then grinded and packed in plastic bags to be ready to the analysis of total ash, proline, total lipids, and crude protein and nitrogen and phosphorus elements as the method mentioned by Association of Official Analysis Chemistry (A.O.A.C) (1990)**.**

The soil: For each of the salinity treatments, the most important soil characteristics were studied, including pH, E.C, CEC and organic matter as the method mentioned by Association of Official Analysis Chemistry (A.O.A.C) (1990)**.**

2. 5. Statistical analysis:

Experiments were carried out according to the design of factorial experiments using the GenStat 12th Edition in the Analysis of ANOVA variation test at the level of probability (P <0.05) for all laboratory analyzes (Yousif, et al., 2006)

III. RESULTS AND DISCUSSION:

3. 1. Seed germination:

Germination started with Rhodes grass seeds from the first day with a germination rate of 20% for both the control and concentration of sodium chloride 100 mM/L, while no germination of the treated seeds observed at 200, 300 and 400 mM/L during the first day. From

5 day to 10 day, reach germination 60% in the control treatment and 200 mM/L, reached up to 80% in the seeds treated with 100 mM/L, and not showed germination in the treated seeds at a concentration of 300 and 400 mM/L until the tenth day (Figure 1). The statistical analysis showed that there were very significant differences in the effect of time (pr<0.001) as well as salinity (pr<0.001) on the percentage of germination of Rhodes grass seeds**.**

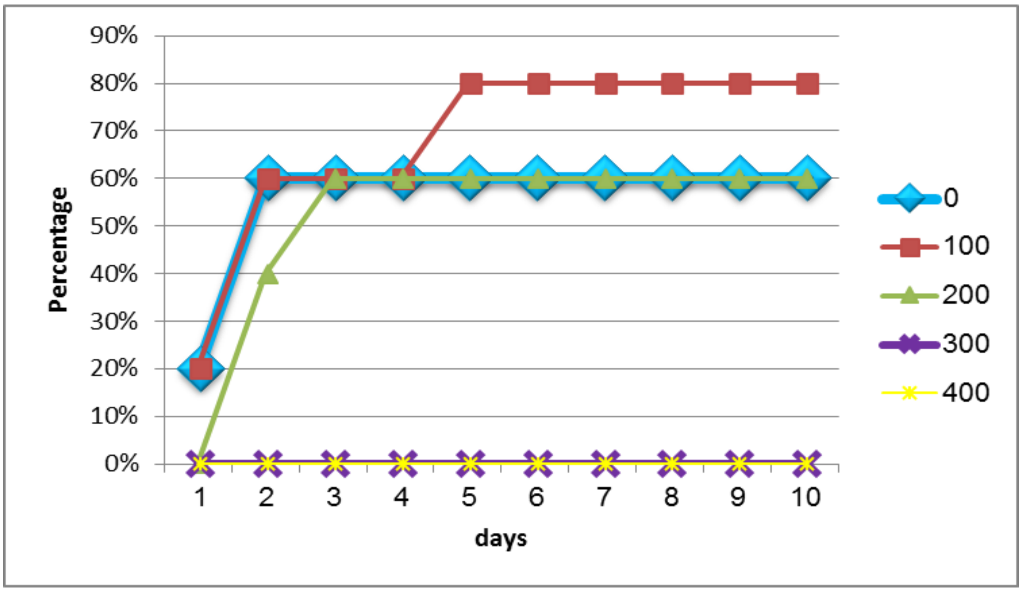

Figure 1: the percentage of germination of Rhodes grass seeds

3. 2. Seedling growth:

The radicle emerged from the first day of the control treatment and 100 mM/L NaCl length of 0.2 cm each as in Fig. 2. And the concentration of 200 mM/L NaCl began on the second day with a length of reach 0.37 cm and continued to grow until the tenth day 1.6, 1.2 and 0.7 cm for treatment 0, 100 and 200 mM/L respectively. While concentrations of 300 and 400 mM/L, treated seeds showed no growth of the root. The statistical analysis showed that there were very significant differences in seed growth in seeds treated with different concentrations of Nacl (pr<0.001) as well as time (pr<0.001).

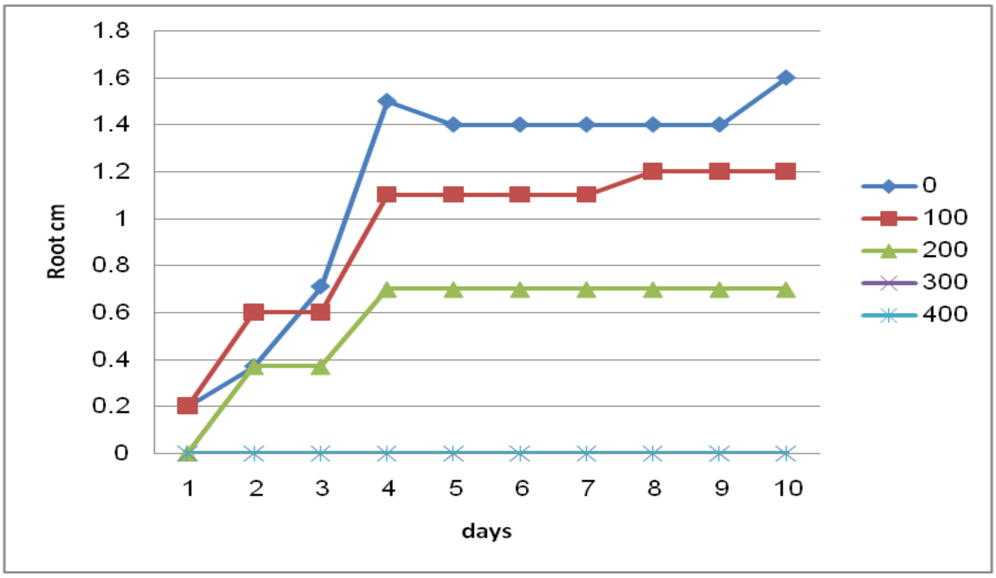

Figure 2: length of root under salinity stress

Figure 3 shows the growth of the rosette, which also started from the first day of control the treatment and 100 mM/L NaCl length reach to 0.2 cm and did not appear during this day in the seeds treated with concentrations of 200, 300 and 400 mM/L.

Thought the second day increased the length of the rosette to the control reach to 0.53 cm and 100 mM/L 0.39 cm. In addition, began to appear in the treatment 200 mM/L with a length of 0.35cm and continued to increase and reached in the tenth day with length 1.9, 1.1 and 0.7 cm for treatments 0, 100 and 200 mM/L respectively. Moreover, did not appear rosette to seeds treated with a concentration of 300 and 400 mM/L NaCl. From the statistical analysis, significant differences were found in the length of the rosette with time (pr =0.005) salinity (pr = <0.001) represented by NaCl.

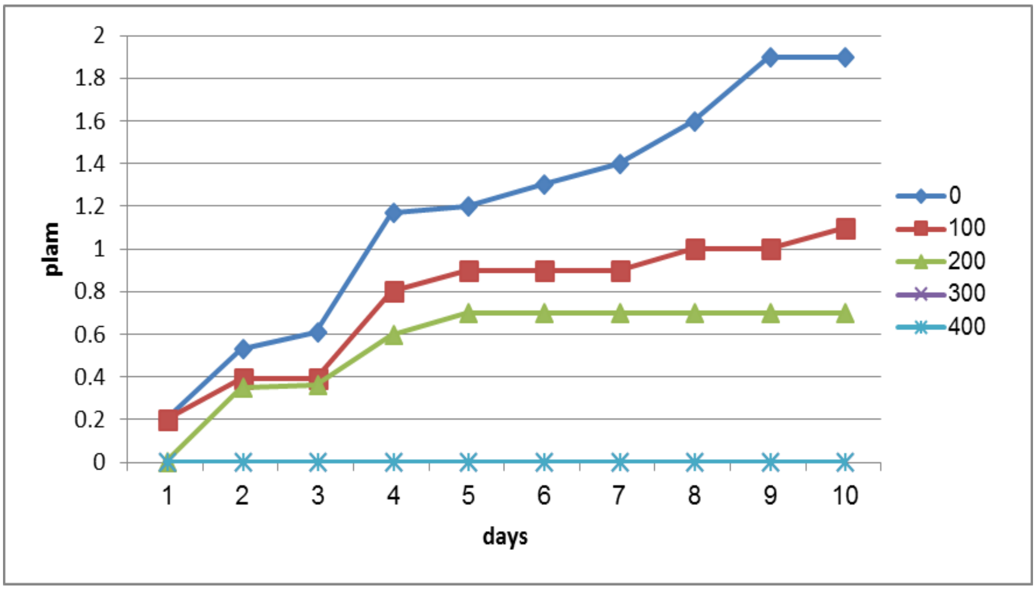

Figure 3: length of rosette under salinity stress

Figure 4 shows the length of the air stem or the rhizomes on which the plant's spread in the environment depends on the formation of new plants through these stems. The appearance of the rhizomes began on the sixth day of the control treatment of the length of reach 0.35 cm and 0.2 cm the seeds treated with 100 mM/L NaCl, and eighth day of 200 mM/L equal 0.1 cm and did not appear rhizomes to concentration of 300 and 400 mM/L NaCl. The statistical analysis has shown significant differences in the appearance of rhizomes of Rhodes grass with salinity (pr <0.001) and time (pr= 0.01).

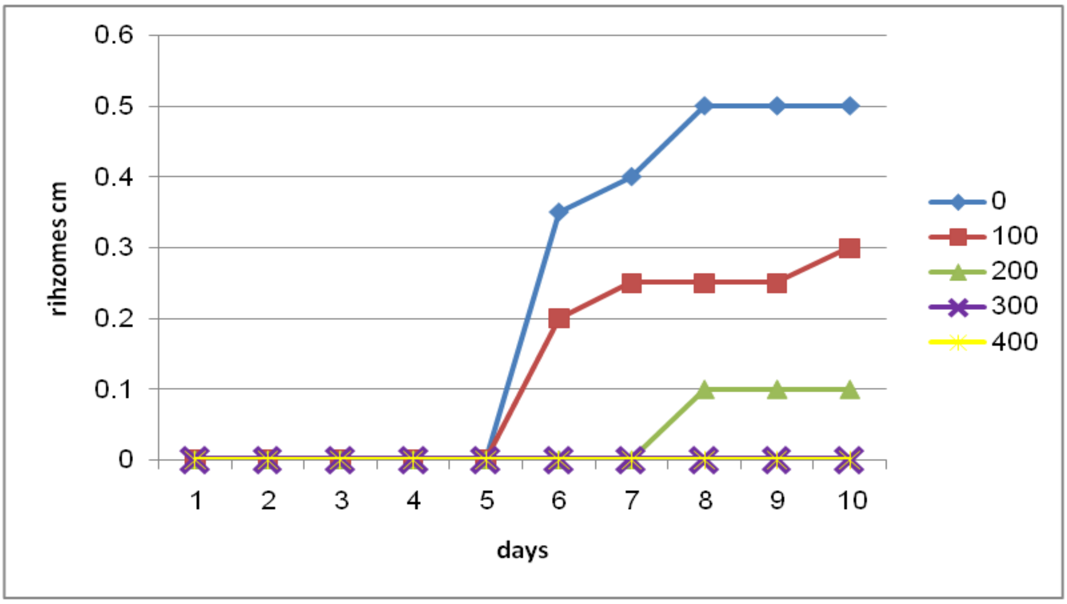

Figure 4: length of the rhizomes under salinity stress

After the formation of the rhizomes, the appearance of secondary root began on the sixth day in the treatment control length, reach 0.13 cm and 100 mM/L NaCl 0.2 cm and continued to grow until the tenth day reached 0.2 cm for the control and 100 mM/L. While the treated seeds 200, 300 and 400 mM/L NaCl no secondary roots were formed (Figure 5). From the statistical analysis, there were significant differences in the appearance of the secondary root of the Rhodes grass seeds under the influence of time (pr=0.02) and the salinity had a very significant effect (pr <0.001).

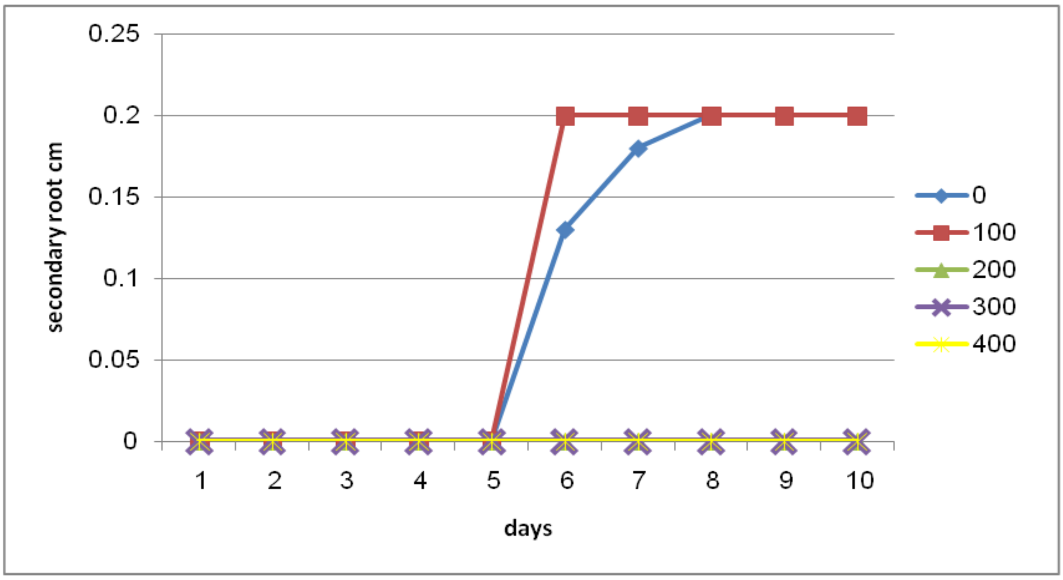

Figure 5: length of the secondary root under salinity stress

The percentage of germination plays an important role in the success or failure of any crop. Forage crops, especially starches, have a greater ability than other crops to resist salinity, but they are less tolerant in the early stages (Al Sger, 1980). This is agreed of the result this study where effect salinity on germination time that is consistent with what it has found Taleisnik *et al* (1997) and Al-Adgham and Al-Suel (2014). Salinity delayed the appearance of rhizomes while the growth of the secondary root was limited to 100 mM/L sodium chloride concentration, which is inconsistent with the results of Córdoba *et al* (2001). It has been shown in many studies that salinity affects crops, reducing the proportion and speed of germination Al-Rahmani *et al* (1997) and Al-Dulaimi (1990) observed a decrease in the percentage of germination of several varieties of barley by 20-50% in increasing concentrations of sodium chloride 50 - 250 mM/L salt level. Which leads to a significant decrease in the percentage of germination and its speed depends on how different plants sensitivity to different salinity.

3. 3. Plant growth:

Plant height:

The best height in the sandy soil reached 60 cm for the treatment of 100 mM/L of sodium chloride, down 8% for the treatment control and 56 cm for the treatment of 200 mM/L for clay sandy soil with a 19% decrease on the treatment control. The statistical analysis showed significant effects (pr<0.001) for salinity stress at the height of Rhodes grass (Fig. 6). This is consistent with what has been found in previous studies as in Waisel (2006) confirms that Rhodes grass is affected by high concentrations of salinity.

Stem thickness:

The best thickness at the end of the salinity stress 8 mm reached 200 mM/L in sandy soil with a decrease of 38% for the control treatment and 9 mm for the treatment of 100 mM/L in the clay sandy soil with 50% less than the control treatment as shown in Fig. 7. There were significant differences in salinity effect (pr<0.001), and time (pr<0.001), and effect of time with salinity (pr<0.001) on the thickness of the grass.

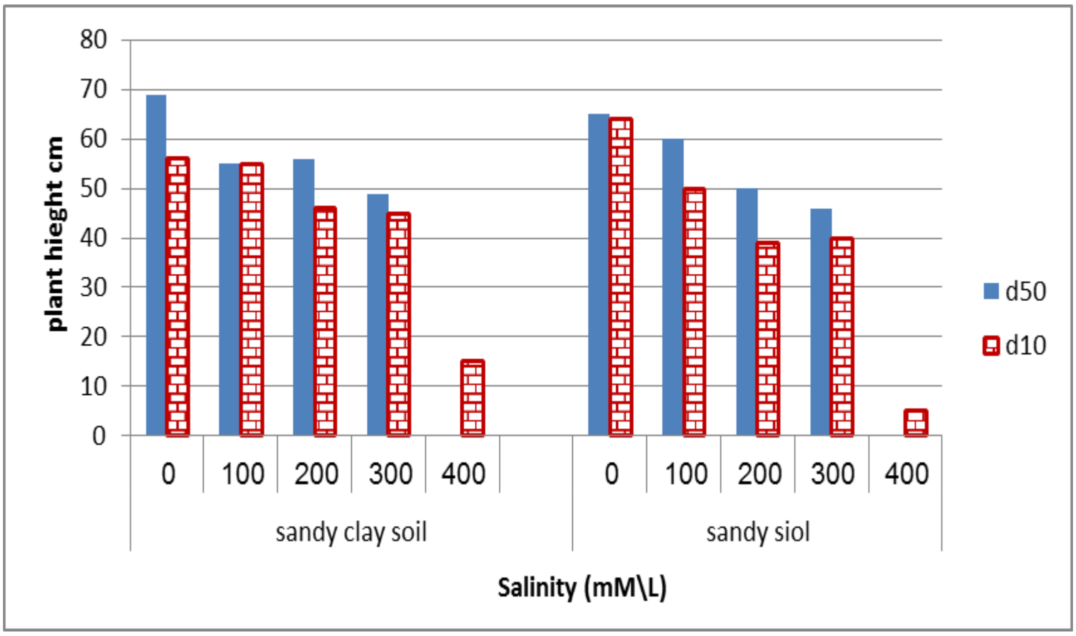

Figure 6: height of Rhodes grass under salinity stress

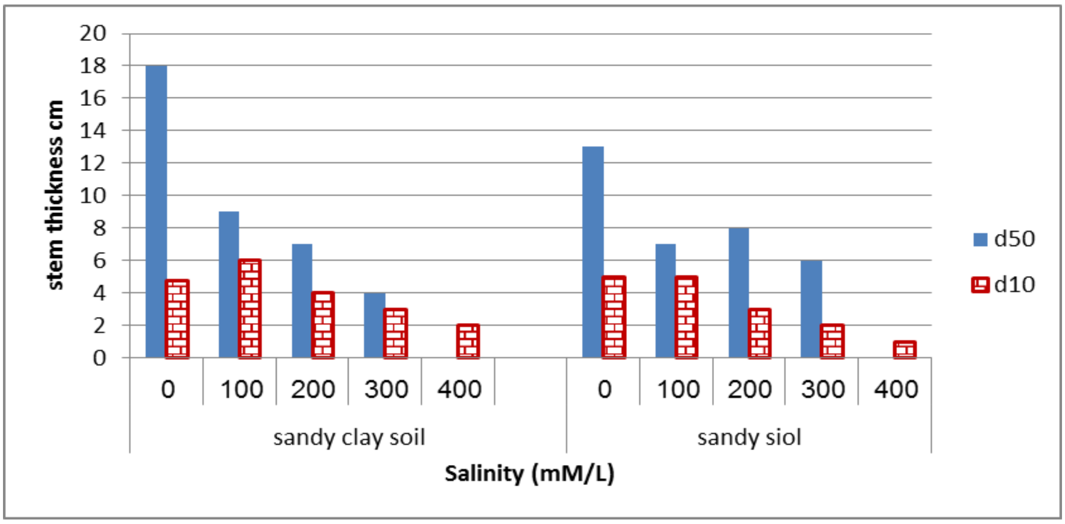

Figure 7: Stem thickness of Rhodes grass under salinity stress

Leaf area:

There were significant differences in the salinity effect (pr = <0.001) on the surface area. In the sandy soil, the area reached 2.4 cm^2 at 100 mM/L, down 8% from the control treatment and 2.24 cm^2 for the treated 200 mM/L for sandy clay soil and down 19% on the control treatment as in Fig. 8.

Salinity has been shown to cause significant reduction of various growth indicators, such as plant height, fresh and dry weight, and leaf surface, mainly due to metabolic processes such as photosynthesis, respiration, protein synthesis, carbohydrates, ion absorption and other characters (Epstein, 1972, Al- Rahmani, *et al*., 1997, Al – Rahmani, 1988; AL- Hadithi, 1992). The disturbance of these processes may be significantly reflected in the productivity of these plants in the unit area (Black, 1973). The results indicated salinity effects on the percentage of damage, reaching 95% for both soils at 300 mM/L and 90% for the control treatment. As noted on these leaves and stems emergence of a layer of saline from the inside and outside of the leaf increased its density by increasing the concentration of salinity treated by the plant and spread this layer about 1 cm from the surface of the plant. These results were agreed with Liphschitz *et al* (1974)**;** Kobayashi and Masaoka (2010)**.** This is in line with the results of García *et al* (2001) and Luna *et al* (2002)**,** in which they demonstrated an increase in the death rate of leaves by increasing stress levels.

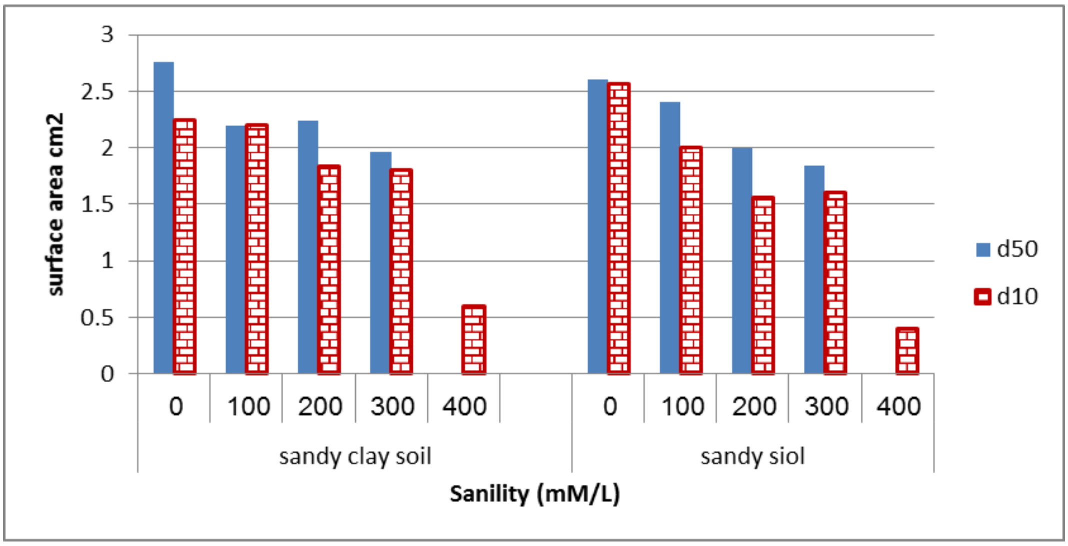

Figure 8: Surface area of Rhodes grass under salinity stress

Root depth:

The root depth of the soil decreased by increasing the salinity concentration until it reached the end of the tube at the end of the salinity stress. In general, the plants planted on the sandy soil reached depths more quickly than the plants planted on clay sandy soils (Fig. 9). The statistical analysis showed significant differences in salinity effect (pr <0.001) and time (pr=0.024) at the depth of the roots of Rhodes grass, while there were no significant differences between the salinity and time (pr=0.034).

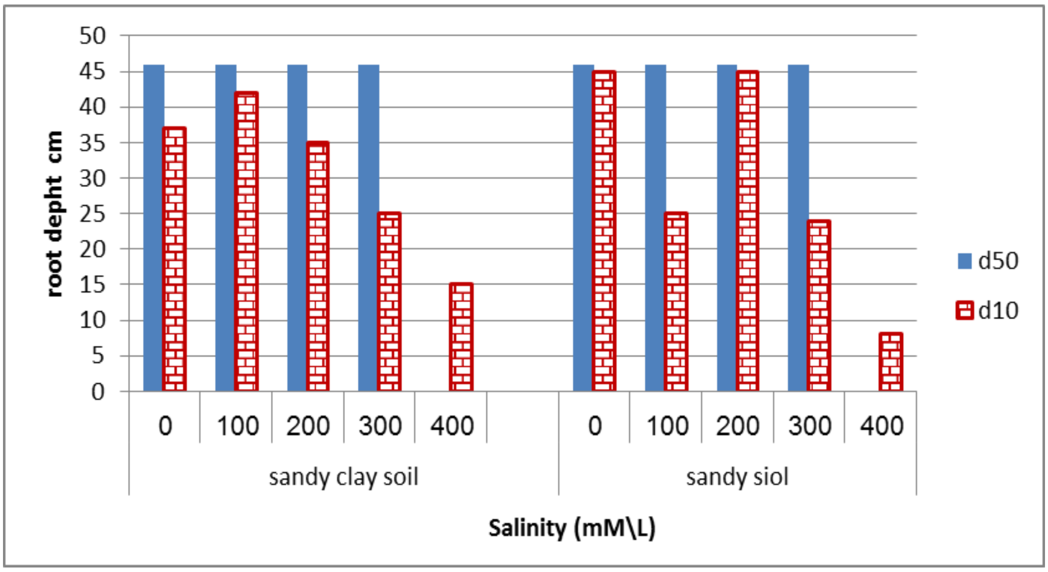

Figure 9: Root depth of Rhodes grass under salinity stress

Percentage of moisture content:

Figure 10 shows a decrease in the percentage of moisture in Rhodes grass with increasing salinity concentrations on both soil types. With a significant effect (pr = <0.001) where humidity decreased with high salinity levels of 40% and 42% for sandy soils and sandy clay soil respectively for the treatment of 300 mM/L and the decrease reached 35% and 30% respectively. Nevertheless, at a concentration of 100 mM/L, the moisture content increased 3% in sandy soils.

This is in line with the results of Al-Adgem and Al-Suel (2014). The water content of all plant cells is an important factor in plant bloating or decay (Brag, 1972). Studies have indicated a decrease in the water stress of cells in response to low water stress for saline-affected soils; these are general responses during the salinity or drought effect of plant water relationships to ensure continuous water movement within the plant (Aspinall, 1986). Abadi and Nasser (2010), found that increasing salinity concentrations in irrigation water caused a reduction in the percentage of humidity and an increase in the percentage of dry matter in the vegetative total of both beans and beans.

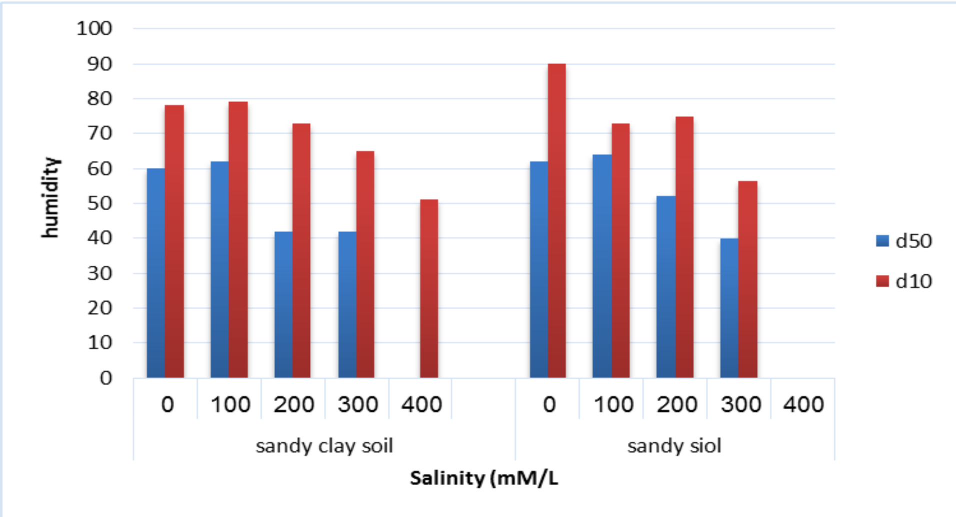

Figure 10: Percentage of humidity in Rhodes grass under salinity stress

Percentage of total ash:

Rhodes grass content decreased from the percentage of total ash by increasing salinity in general by 6% from the treatment control of the treatments 300 mM/L for sandy soil and 14% less than the control in clay sandy soil. As shown in Figure 11 the total ash ratio was 71.25% for the treatment control, 70, 64 and 66.75% for the treatments 100, 200 and 300 mM/L NaCl respectively. In addition, in the sandy clay soil, the total ash percentage reached 81.25% for the control treatment and decreased to 76, 67.25% and 70.25% for 100, 200 and 300 mM/L NaCl respectively. Statistical analysis shows significant differences in salinity effect (pr=0.001) and time (pr=0.024) to the content of Rhodes grass of total ash.

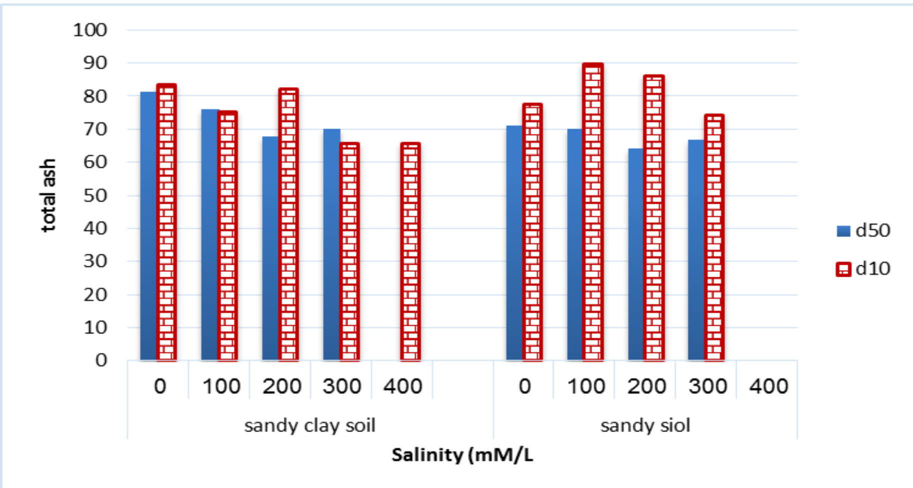

Figure 11: Percentage of total ash in Rhodes grass under salinity stress

Soil characteristics:

pH and electrical conductivity:

The pH values for this study were approximated over days for all salinity treatments of Rhodes grass plants where pH in these soils between low acidity and weak alkalinity as in Fig. 12 increased relatively by increasing salinity. In sandy soil, pH increased by 1% and 12% sandy clay at 200 mM/L. However, saline soils generally have high pH values of up to 8.5 (Abadi and Nasser, 2010). There are significant differences in salinity effect (pr = <0.001).

The same was true for electrical conductivity with a significant effect on the effect of soil type (pr<0.001), and salinity (pr = 0.004), and time (pr<0.001). In general, the electrical conductivity in clay-sand soil was greater. Of sandy soils decreased with increased growth time as in Figure 13.

Studies indicate that saline soils have a higher electrical conductivity value of more than 4.0 ds/m (Abadi and Nasser, 2010).

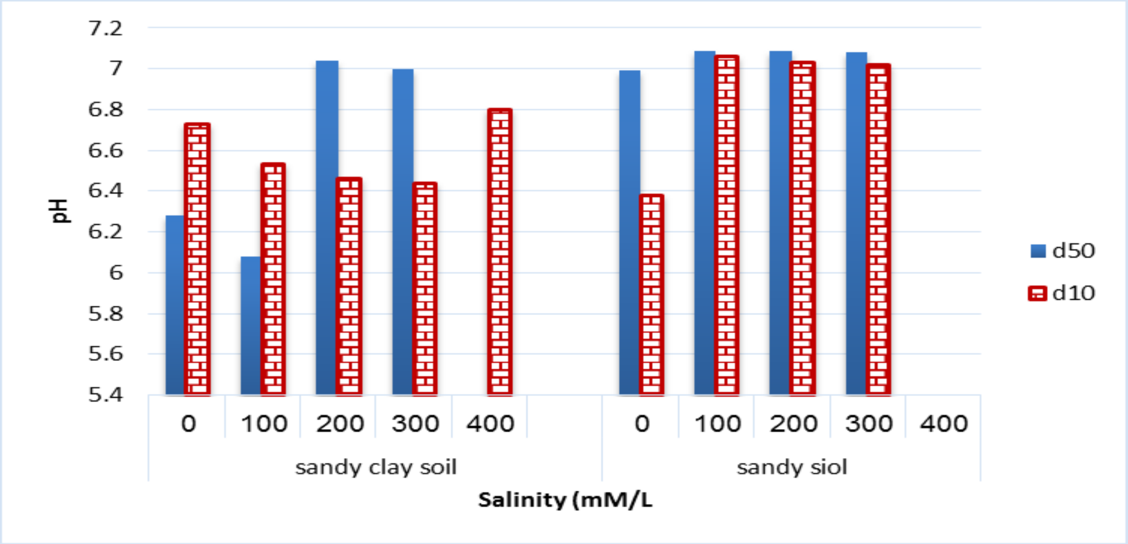

Figure 12: pH in soils under salinity stress

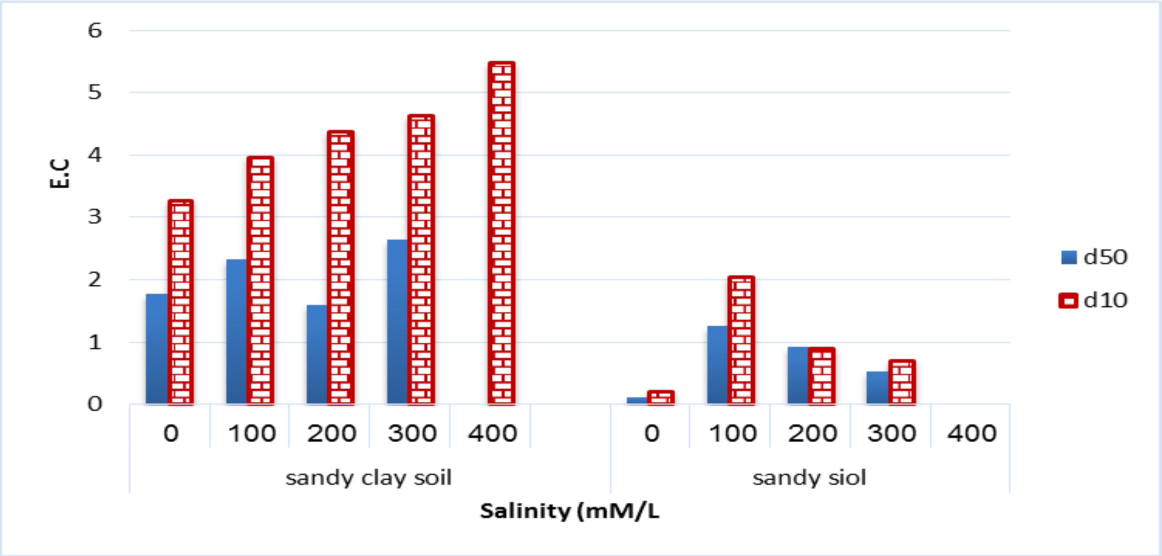

Figure 13: Percentage of electrical conductivity in soils under salinity stress

Cationic exchange capacity and organic matter:

The results showed an increase in the cationic exchange capacity of sandy clay soil more than in the sandy soil as shown in Figure 14, where it was high on day 10 and decreased in day 50 in some treatments. The results of the statistical analysis showed no significant differences in the effect of salinity on cationic exchange capacity**.**

The results indicate a rise in the ratio of organic matter 50 days after the treatment of Rhodes grass with graduated concentrations of sodium chloride in sandy soil and sandy clay soil. The increase in sandy soil was 1.96, 1.95, 1.84 and 1.93% for treatment 0, 100, 200 and 300 mM/L NaCl is more than 1.94, 1.88, 1.93, and 1.92% clay sand for treatment 0, 100, 200 and 300 mM/L NaCl respectively, although the primary concentrations in clay sandy soils are higher as shown in Figure 15. Statistical analysis shows significant differences in salinity effect (pr= 0.022).

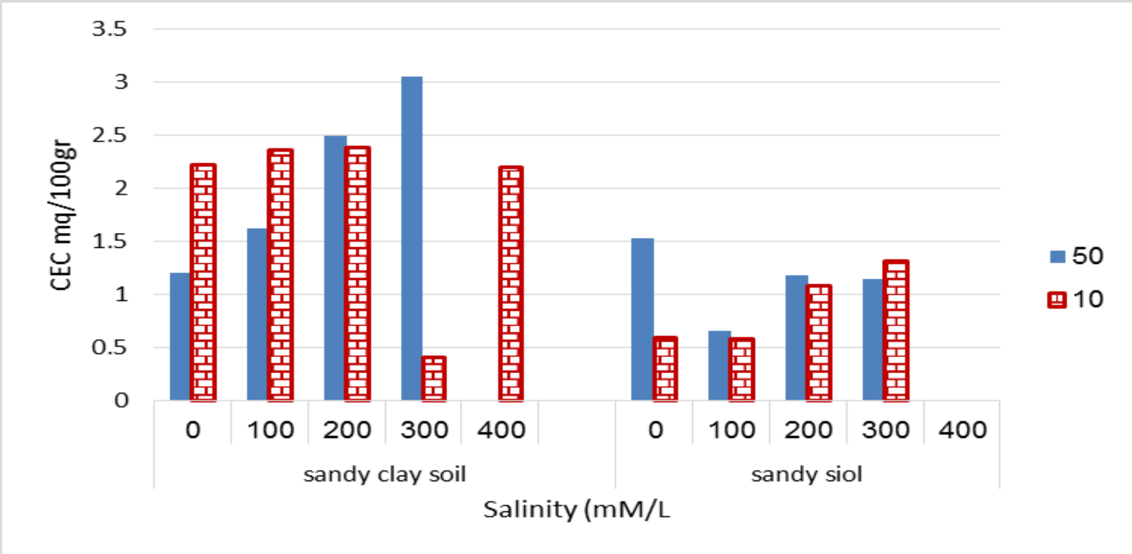

Figure 14: Cationic exchange capacity in soils under salinity stress

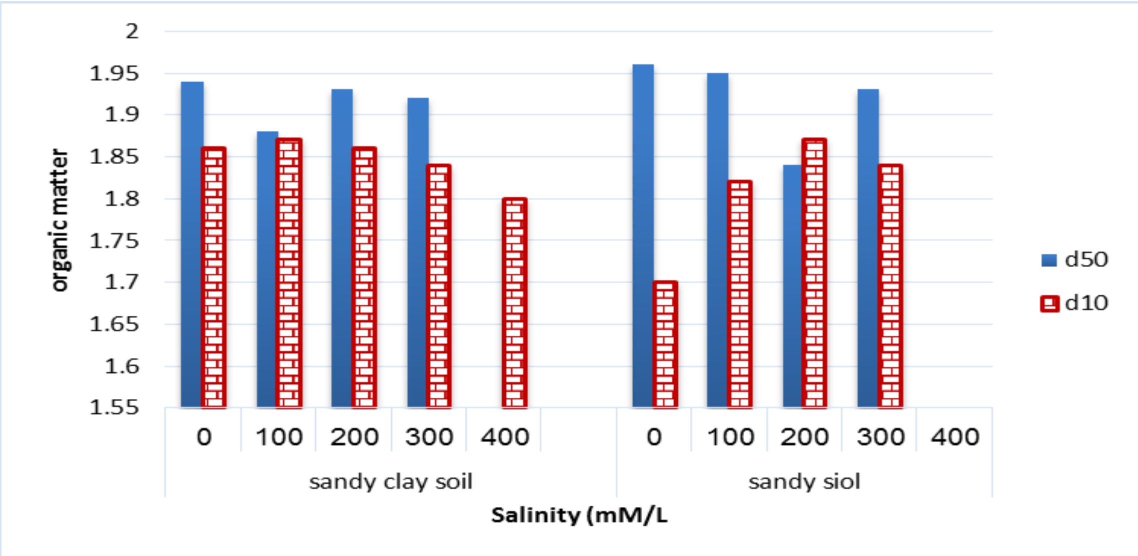

Figure 15: organic matter in soils under salinity stress

The study showed low concentrations of salinity up to 200 mM/L of sodium chloride does not affect the process of germination and growth of Rhodes grass. The safety limits for cultivation are located in the range of this concentration, to exclude the salts by releasing them from the vegetative parts especially leaves. Rhodes grass exposed to low levels of stress at the beginning of its growth stages, helping it adjust during its growth during this stress. For example, its growth on sandy clay soils helps them withstand stress more than plants in sandy soils. It recommended cultivating Rhodes grass on the soil softer for the growth of the first day and for easy spread and composition of the rhizomes or mixing the seeds with sand before planting to improve growth Rhodes grass does not grow when covered with a layer of more than 2 cm soil**.**

When cultivating Rhodes grass on sandy soil, it is preferable to compensate for the sandy soil because the sandy soil is deficient in nutrients necessary for plant growth. Rhodes grass grows under stress and reduces its overall nutrient content so its early use as animal feed is more useful than the late stages of its growth.

IV. CONCLUSIONS

For many years, saline lands have been a problem for agricultural investment, so this study aimed to evaluate the growth and productivity of Rhodes grass under the conditions of the environmental stress of salinity on two types of soils (sandy soil and sandy clay soil) in Wadi Al-Shate region (in southern Libya) in summer 2013. By determining the percentage germination and growth indicators of seedling and measurement of some of the apparent characteristics of the vegetative and root, as well as the study of the most soil characteristics affecting plant growth. The results showed the ability of the plant to grow during soil salinity up to 300 mM/L sodium chloride but with significant damage, and it is noticed that it excretes these salts through the vegetative part of the plant. The results also showed adverse effects of salinity stress on plant height; stem thickness, surface leaf area, percentage of dead plants, and percentage of plant moisture content. Saline stress had adverse effects on root depth and density. It had a high ability to extend their roots quickly during its first stages of growth, during 30 days and characterized by a great radical cohesion. Salinity also harms soil acidity and organic matter, the electrical conductivity of the soil increased by salinity. Sandy soil found to have a positive effect on the growth and depth of Rhodes grass.

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Isma. M. Abdorlhman, et. al. “Evaluation of salinity effect on growth and productivity of Rhodes grass (Chloris gayana)." *International Journal of Engineering Research and Development*, vol. 17(04), 2021, pp 28-38.